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Philosoph. Transact. Number, 10

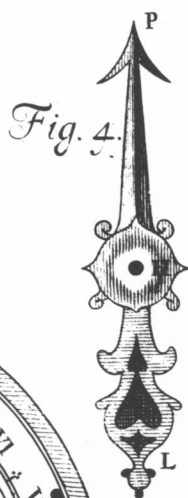
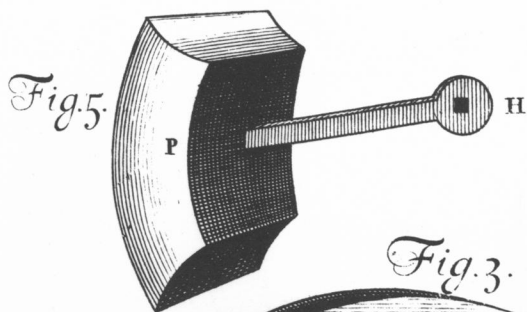
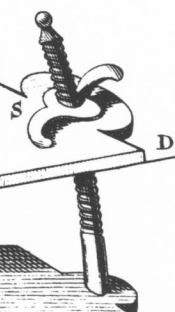
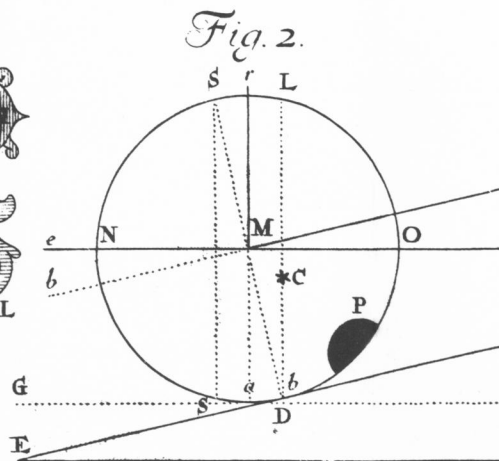
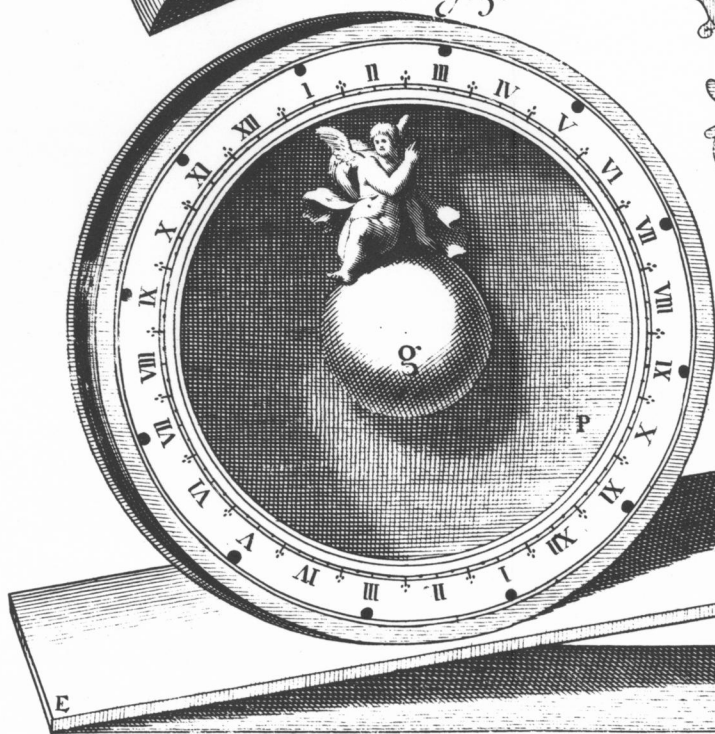
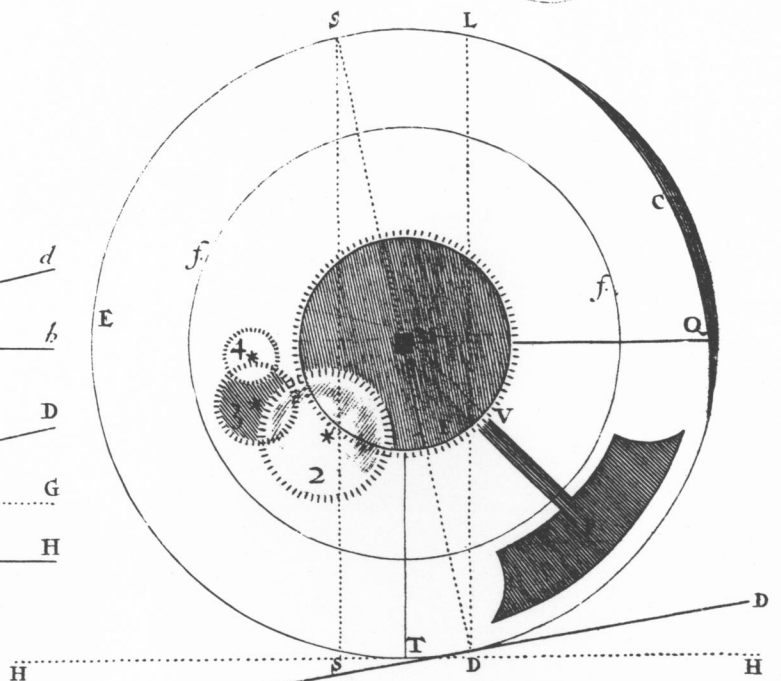
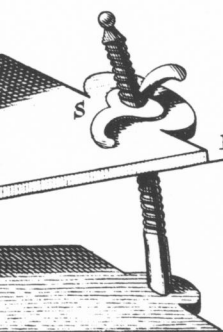
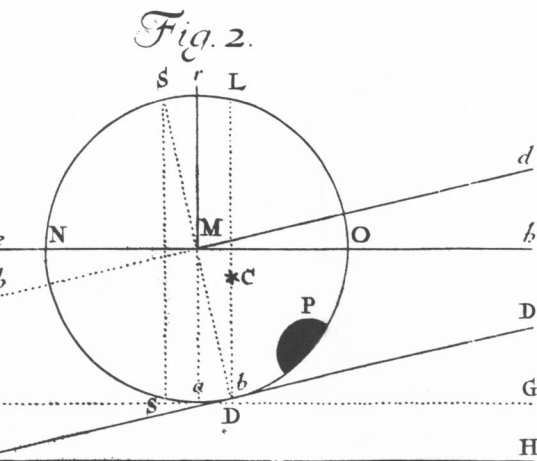


Fig. 3.



act. Number, 161.

Fig. 1.



M. Burghers sculp.

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Philosophical Transactions

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A Letter from the Learned and Ingenious Maurice VVheeler M. A. and Rector of Sibbertoft in Northamptonshire, to the Publisher of these Tracts, concerning a Movement that measures time after a peculiar manner, with an Account of the Reasons of the said Motion

Hon. SIR,

THE Relation which I have, and the great Respect that I bear to the lately erected *Philosophical Society* in *Oxford*, will ever oblige me to serve it in the meanest offices, if thereby I may contribute the smallest Advancement towards that noble Design they are in pursuit of. Wherein, forasmuch as an Attempt is vigorously (and in the issue I hope successfully) carried on, by the communicated Observations and united Counsels of ingenious and learned Persons in this and other Nations, to improve the knowledge of things to the real use, or (at least) the sober delights of mankind by your encouragement; I have herewith (and as my first tribute,) presented to the consideration of our Society, the Scheme and Contrivance of a *Movement*, which measures time indeed by *Number, Weight and Measure*; but after a manner so peculiar, and in several of its properties so surprizing, and of a structure so unexempl'd; as you your self (if the invention be worth the owning) can vouch me to be the sole Author of. For altho the late *Lord Marquis of Worcester* is said to have contriv'd a Watch that should move upon a declivity, as this (hereafter describ'd) is intended to do, and *Monfieur de Gennev* in the *Philosoph. Transact. Numb. 140.* has given some account of a *Clock* ascendent on a *Plain* inclin'd. yet neither of them, nor any like them, was ever seen by me, and for ought I could ever learn, the *Reason* of their *Motions* remains

to this hour as great a Secret, as if they had never been.

Now whether I have discover'd this or no, will appear from the Account I am now about to give thereof; which I sha'l deliver with all the clearness I can in this method following. 1. By proposing the State of the *Problem*, or declaring what is to be done. 2. By offering at a Solution thereof, and shewing from allow'd Maxims in *Statics*, and other Principles proper to the Question in hand, the Reasons how, and the Causes whereby it may be effected.

1. The state of the *Problem*, may be compriz'd in these four particulars; by describing 1. The *Movement* as to its exterior structure 2. The manner of its motion, as it appears to the Eye. 3. The use thereof in the measuring of time. 4. The way of adjusting this Motion to the exact divisions of an hour. All which foremention'd particulars (were the *Movement* actually made,) would be obvious to the apprehensions of any Spectator, who perhaps might never be able to comprehend the Reasons of the Motion it self.

1. For the exterior structure of the *Movement*, be pleas'd to see *Fig. 3.* which represents a circular body of 3 inches $\frac{1}{2}$ diameter, consisting of 2 plates measur'd by the same *Radius*, and fixt in a parallel position to each other by the hoop, (*b.*) the bredth of which is about an inch. This hoop and the 2 Plates form the Case of the *Movement*; of which, that which appears in the front, is towards the verge thereof inscrib'd with a horary circle, the divisions whereof answer the hours of a natural day. The deep shades within this circle are intended to represent a Concave, of near half an inch deep; and the prominence (*g.*) in the middle of this Concave, is a hemisphere of Brass or Silver, riding loosely on a pin, which lies hid, and is the *Axis* of the *Movement*. The upper half of this hemisphere is hollow, but the nether fill'd with Lead; and the small Gentleman that sits thereon, does with an erected finger perform the office of an *Index*. The Reason why this

plate

plate is concave, is grounded upon no necessity; but since the structure of the internal parts will very well admit of such a figure, and it comported pleasingly with a fancy I had of rendering the front of the *Movement* more beautiful, therefore *currente rota* (as the Poet speaks,) I gave liberty to my pencil to describe it in this manner. But if the hemisphere with the figure thereon, shall seem a piece of work too elaborate for the end it serves unto; and for the sake of which the Dial-plate is form'd into that shape: I have (*Fig. 4.*) drawn a plain *Index*, which you may substitute in the room thereof, or any other, (as it shall please the Painter) provided that the *Axis* whereon 'tis supported, move freely in the hole (*H*); and the lower part thereof *H. I.* may so far preponderate to *H. P.* as always to keep the *Index* pendulous, with its point to the vertical hour.

2. For the manner of its motion, as far forth as it appears outwardly, it is thus; *S. E. Fig. 3.* represents a board or shelf, of a strait and even surface, about 6 foot long, and so thick as not to be apt to cast with change of weather; nor to grow *Camber* under a small weight; on this is the *Movement* plac'd and here to perform its course, and therefore I call it the *Stage* of the *Movement*. This *Stage* is rais'd at the end *S.* about 10 degr. above the Horizon or line of level *H. E.*; but the Angle of its declivity *D. E. H.* is variable, as will hereafter appear; and although it happens in the Scheme to be 10 degrees, yet I would have it understood to be indefinite at present, till I come to shew the causes that will determine its quantity. The 2 plates which form the Case of the *Movement*, are to be extant all round without the hoop (*b.*) $\frac{1}{4}$ of an inch, and the edges of 'm lightly indented; that while the *Movement* descends upon the *Stage* it may turn only, and not slide.

3. The use thereof in measuring time, is as follows. The *Movement* being plac'd as high as it may, near the point (*S.*) shall move downward towards *E.* with that

flownes, as to finish one entire Revolution in 24 hours; and while it does so, the divisions on the horary circle (or Dial-plate) successively culminating over the point of the *Index*, will show the hours of the day and night. For in this Movement (contrary to what is usual in others) the hour is discover'd by the access of the numbers to the *Index*; which (as was said *Par ic. 1.*) is always to keep the same Position. Now when by several repeated Revolutions it has measur'd out the length of its stage, it is to be replac'd at S. as before; which may be done in less than half the time you are winding up a Watch; and if the stage be but 6 foot long, no oft'ner then once in a whole week.

4. The way of adjusting this Motion to the exact measure of an hour, and rectifying its errors; comes in the last place to be provided for. No Movement could ever yet be found, that would keep pace with the Sun; and the Reason of this, besides the alteration of weather, and other common accidents to which the most curious Movements are liable; is because the Sun it self does not always keep the same pace, nor is the precise duration of a solar hour in any one day so exactly assignable, as to serve indifferently for the whole Year round. But leaving that *Astronomical Enquiry* to such as have better helps and opportunities for Celestial Observations; I shall crave leave to think, that if no greater objection can be rationally made to this Movement, then the necessity of its being sometimes adjusted and rectify'd; even this will appear a very inconsiderable one, since the manner of doing it, is so very obvious and easie. To explain this, 'tis to be consider'd that there are two Errors which every Movement is subject to, and indeed scarce ever entirely free from, tho when the aberration is so small as not to be discernable, it passes for truth. The first of these is, when a Movement gives you a wrong measure of an hour, by going remarkably too fast or too slow; and this is an error in the whole train of the Movement from the beginning to the end. The second Error is,

when

when the *Index* points to a wrong time ; and this happens either 1. By consent, when it follows the Error of the Train; for while the Movement goes too fast, or too slow, the *Index* can never be right Or 2 It is a *Solitary Error* in the *Index* only, when the motion of the Train being duly adjusted, the *Index* it self is not set exactly to the (*το νυν* or) present instant of time on the Dial-plate.

1. Therefore, to remedy the former error which lies in the whole Train ; we rise our Watches up or down (as the case requires) by turning the endless skrew, or by removing (either forward or backward) the *Retinaculum* or Brace of the spiral spring ; and in *Pendulums*, by giving the Boss a turn or two upwards or downwards : but in this Movement (if so be it shall happen to prove one,) the adjustment is readily perform'd without ever tampering with the Movement it self ; for by a skrew inserted in the *Stage* at (S.) with the turning of which the *Stage* may be elevated or depress'd, I affirm that the Movement will go faster or slower : faster, if rais'd up ; and slower, if let down.

2. The motion of the Train being thus adjusted (as near as may be) to the true measure of an hour, the error of the *Index* will be rectifi'd thus I said before, that the *Index* is always to hang in the same position, and therefore cannot be turn'd to the time, but the time must be brought to it ; which is readily done by making the *Hourary Circle* movable, and inserting several small bosses or buttons here and there upon the verge thereof whereby (with an easy touch of the finger) it may be stirr'd to the right or left, as there shall be occasion.

AND thus *Sr.* you have the *Problem* propos'd, and nothing material omitted in the description of the intended Movement, either as to its external structure, or the manner how it moves in the measuring of time, or the way how it is to be adjusted and rectifi'd: You have heard both what it will do of it self, and what is to be done with it ; in all which I affirm it will fully answer your expectations and mine, for proof whereof I hasten to the remaining part of my discourse, which contains,

II. THE SOLUTION of the *Problem* propos'd ; wherein I shall endeavour to show from allow'd Maxims in *Statics*, and other Principles proper to the Question in hand both the Reasons how, and the Causes whereby this may be accomplish'd.

1. Then, because it may seem at first view a little surprizing, that a circular body should rest (or which in the present case is all one, move so imperceptibly slow) upon a descending plain, having no visible impediment either to stop or retard

tard the *impetus* of its own weight: therefore to explain this, be pleas'd to see *Fig. 2.* where first. Let the circle (*L. O. D. N.*) represent any circular body whose centers both of gravity and magnitude are coincident at *M*. Let this circular body be plac'd upon some level plain *GG*. and then 'tis evident that the Angle of its contact with that plain at (*a*) will also be the point of its Libration, and consequently it must needs rest there; *Quia momentum & imp. circumscriptum sunt æqualia.*

2. Let *DE* represent a descending plain, making an Angle of contact with this circular body at (*a*) and here, 'tis manifest it cannot rest; because the *Line of Direction* (*ra.*) which (while it infist'd on a level) divided the circular body by the centers of magnitude and gravity into parts æquiponderate, is now remov'd to *LD*; which line *LD* falling without or beside the center *M*. evidently destroys the æquipoise of its parts, and therefore must leave it to tumble down towards *E*. for here *Momentum impeditur majus*. The reason therefore of its descent now, being the overballance of the parts *LND*. to the remaining Section *LDO*. it must necessarily follow.

3. That if some weight equal to the excess of *LND*. above *LOD*. were affixt to the limb of the Quadrant (*O, a.*) as at *P*; then the circular body would rest as quietly at (*b*.) as it did before at (*a.*) The supposition cannot be denied, and the consequence is unavoidable, because $LDO + P = LND$, *i. e.* *Impedimentum æquatur Momento*. Nay I affirm that this circular body shall now resist a greater force, and maintain its point of libration (*b*) more pertinaciously on the declivity *DE*, then it could before, when it rested on the poyn't (*a*) in the level *GG*. The reason of which, is evidently this; because by the addition of the counterpoise *P* to the Quadrant *Oa*, the center of gravity falls lower in the line of Direction *LD*, and is remov'd from *M* to *G*, *i. e.* nearer to the poyn't of libration (*b*): and consequently will keep the circular body more steady in its present Position. From whence if it be remov'd about 7 or 8 degrees of the Quadrant from the poyn't of Libration (*b*) either upwards or downwards by a motion of volutation, it will vibrate briskly till it recover its poyn't of quiescence: whereas any globular body having the same centers of Magnitude, and Gravity, and infisting on a level; as it is turn'd with a very light impulse, so as soon as its circular motion ceases, it never undulates one jot, but rests immediately.

THUS it appears evidently (as to me it seems) how such a circular Body as is describ'd *Fig. 3.* may be made to rest upon the descent *SE*: which if I have prov'd, more than half the difficulty of the *Problem* is solv'd; for what I have already

dy offer'd towards it solution, has been but as it were the winding up of the Movement in order to make it go ; and it will appear from what follows, *That the same principle, which hitherto has bin the cause of its REST, shall from henceforth be the cause of its MOTION.* To this purpose, be pleas'd to observe *Fig. 1.* where the same Movement, which was sciagraphically describ'd *Fig. 3.* is for the better discerning its internal structure, and explicating the reason of its motion, represented in naked lines. Here then, let the numbers 1, 2, 3, 4. represent a train of wheel-work, wherein there is no material difference from what is found in a common Watch ; only the numbers of the teeth on the wheels and pinions are to be so calculated, that the motion of the whole train may correspond to the assign'd Revolution of the body of the Movement, which is to be once in 24 hours. It would be expedient also, that a spiral spring were applied to its Ballance, as in the latter Movement is usual ; but of a *Use* here's no need, for the turns of the body of the Movement as it descends upon the Stage, answer all the intentions of a string or chain ; and the contranitence of the weight *P* to the excess of *LED* above *L QD*, serves instead of a perpetual spring ; and the Movement wants only a perpetual descent, to make its motion so. And whereas the great wheel in ordinary Movements, is plac'd as near the edge of the framing plate (*ff*) as it may be ; here it must (with its *Axis* or *Arbor M*) possess the center of the Movement : because this wheel is to carry the weight or power *P* by the *Vetus MP*, and that weight *P* must always keep an equidistance from the center of the Movement, that while the body thereof (*i. e.* of the Movement) performs its Revolutions ; the said weight *P* and the great wheel (to which it is affixt,) may without any considerable variation, continue in or near the same Position, wherein they now are. Now for a while, be pleas'd to suppose this weight *P* with its *Vetus MP*, to be taken quite out of the Movement, and laid aside : and and then conceive the body of the Movement to be plac'd on a Horizontal plain *III*, its point of contact in that plain where it should, but cannot rest, is *T* ; because the weight of that part of the Train mark'd with the numbers 2, 3, 4 removes the center of Gravity from *M*, and therefore on the opposite part of the Movement as about *C Q*, the inside of the hoop which forms the Case is to be loaded with a thin lining of lead, which may be a counterpoise to that part of the train ; that so the whole body of the Movement, together with all its furniture within and without (excepting only, that *P* with its *Vetus* is as yet laid aside ;) may on that Horizontal

horizontal plain, or while it rides upon its own *Axis*, rest indifferently in any poyn^t. This reducing of the Movement to an equilibration of all its parts in the center M, must be perform'd *tentando*, i. e. by rasping the lead at C \mathcal{Q} , as much and in such places as is needful; which to an Artificer of ordinary sagacity, will not be at all difficult.

THE center of gravity being thus reduc'd to M, the next thing that follows, is the replacing of the weight P; which, for the better representing its shape, is drawn according to the dimensions of its solidity as *Fig. 5.* and by the hole H, is to be set on the *Arbor* of the central wheel M. Now let the body of the Movement be plac'd on the Declivity D E, and supposing (as was shew'd above *numb. 3.*) $P + L QD = LDE$, then the body must needs rest there: but because the weight P is not now (as in *Fig. 2.*) fixt to any part of the Quadrant QD, but hangs upon the train of wheel-work 1, 2, 3, 4. it evidently follows that if the power thereof be superior to the resistance of the train, then the whole body of the Movement must needs descend towards E in *Fig. 3.* By this you see there are 2 offices assign'd to the weight or power represented by P in *Fig. 1.* or *Fig. 5.* whi^h if I can make evident it will perform, I conceive this will be a complete Solution of the *Problem*. The

1. Is, to be a counterpoise to the excess of the weight of L E D, above L Q D; which that it may be, upon the reasons given in the explication of *Fig. 3.* I now crave leave to take for granted. The

2. Is, that it be of force sufficient to put the train into a motion so adjusted, as may exactly comport with the time assign'd for the revolution of the whole body. So that if there be any difficulty remaining, it consists in such an exact stating of the weight and power of P, that it may adequately serve both these intentions. Now how very easy this is, will be manifest from these Propositions following.

1. That whatever the intrinsic weight of P shall be, (as suppose it 4 ounces Troy;) yet the power of that weight will be augmented or diminish'd according to the different degrees of its elevation in the Quadrant T Q. Thus considering P M as a Vectis, its *Hypomochlium* (for want of an English word) is M, the point where it exerts its power on the train, is at V. I say then, that whatever power it has upon the poyn^t V in its present elevation of 45 degrees; it will acquire a greater by being rais'd to 50, 55. &c. and the greatest of all in 90 degrees at Q; and on the contrary, let it sink to 40. 35, &c. its power upon the point V will still be diminish'd, in so much that in T it will be utterly extinguish'd and

and in respect to any influence upon the train, 'tis in that position (as the Poet speaks) *Necquicquam nisi pondus iners*. I need not spend time to demonstrate this Proposition, considering to whom I write; and therefore upon the pr sum'd concession thereof, this consequence must be allow'd: that if P be of a competent weight (*i. e.* not utterly too light) to move the train at all, it will certainly move it in some degree of Elevation or other in the Quadrant Q T.

2. If the weight P be consider'd as to its office of being a counterpoise to the body of the movement; as I need not prove, that it will perform this no less while it hangs by upon the *Veclis* MP, then if it were fast rivetted in the same place to the case of the Movement: so I affirm, that in what poynt of the Quadrant soever it will move the train, it may be also a counterpoise to the Body of the Movement. This proposition is not altogether so evident, but most certainly true, as I hope in what follows clearly to demonstrate. Be pleas'd therefore, to observe

1. That at what poynt soever of the Circle L E T Q *Fig. 1.* the line of Declivity D E makes an Angle of contact; on the same poynt will the Diameter S D fall at right angles with D E.

2. That the line of direction L D will ever fall upon the poynt of Contact D, making an Angle with the Diameter, as S D L. These 2 propositions need no proof.

3. That the Angle S D L will be always equal to D E H in *Fig. 3.* *i. e.* As great as is the elevation of the line of Declivity D E above the Horizontal E H *Fig. 3*: so great will the Angle of distance be between the Diameter S D and the line of direction L D *Fig. 1.* To prove this see *Fig. 2.* where let E H represent the Horizon, E D line of declivity; to E H draw parallel *e h*, and to E D parallel *b d*. therefore Angle *d M b* is equ to D E H, and *e M b* equ. to *d M b*; and because S M b and r M e are right angles, therefore is S M r equal to *e M b*, and *r a* being parallel to L D, the Angle S D L must be equal to (S M r, = e M b, = d M h, *i. e.* = to) D E H. and from hence it follows.

4. That the greater the Angle of declivity is in *Fig. 3.* the less will the Section L Q D be in *Fig. 1.* and so on the contrary, the less that Angle is, the greater the Section. And therefore,

5. The excess of the weight of L E D above L Q D must be also greater, by raising up the stage with the screw at S: and that excess less, by screwing it down.

6. The lighter that part of the body is, which is represented by the Section L Q D; the more heavy ought the

counterpoise P to be, and that either in its owne intrinsic weight (in Ounces and parts of Ounces) or else in its potential weight, by being rais'd higher in the Quadrant Q T.

7. The skrewing up the Stage of the Movement at S *Fig. 3.* will raise the Counterpoise higher in the Quadrant Q T. by *Prop. 3* and therefore potentially heavier. And from hence appears (I take it most clearly) both the reason of the due adjustment of the motion of the Train to the exact measure of an hour, and what weight is to be assign'd to P, that moves it ; and that we are not confin'd to scruples and grains, but are allow'd such a considerable latitude, as it is not easy to erre therein. I shall give a word or two for direction in that Particular and conclude. Therefore having set the Stage (by the help of the arched Skrew) at the elevation of about 10 degrees ; place the Movement thereon, and try what weight hanging at the end of the *Vectis* MP while stir the Train, meanwhile holding the Movement with the hand in such a position, as the *Vectis* may make an Angle of about 30 degrees with the perpendicular MT: then let the Movement loose to undulate upon the Stage ; and when the vibration ceases, observe to what degree of the Quadrant the *Vectis* poynts, and at the same time mind the pulses of the Ballance. If at this Observation, the weight lies low (as for instance between 25 and 35 degrees of the Quadrant) and the beats of the Ballance are guess'd to be not much different from their due time ; the weight P is well enough proportion'd ; for herein (as I said) there is a considerable latitude, and if it chance to be much heavier then is absolutely needful, that excess will be moderated by skrewing down the Stage ; and if it be not absolutely too light, its defect will be compensated, by skrewing the Stage higher. Therefore of these two extremes, choose the former ; for the fewer degrees that P arises in the Quadrant beyond what is absolutely necessary, it will (for reasons very obvious) be so much the better.

And thus Sir, if I have not err'd in my apprehensions ; you have presented to you the Scheme of such a Movement, together with the demonstration of it's Motion, as will fully answer the Problem propos'd. Upon the careful review of what has bin said, tho I find some defects in poynt of method, and not alwaies so natural a Syntax in the periods as might have bin : Yet I thing neither of that consequence, as to render my meaning any where unintelligible, or my reasons less conclusive ; tho both of them I acknowledg to be such faults, as not to deserve your pardon without a just excuse. I have drawn consequences from some assertions not prov'd,

prov'd, because I judg'd them unquestionable to any that know the undoubted principles upon which they are founded: and it would have bin an unpardonable trifling with your patience, upon every occasion to demonstrate $2 + 3 = 5$ with the formality of an *ὡς περ ἐστὶ δεικνύται*. Notwithstanding which I confess I am too long, and that for want of more time: and yet perhaps had I staid longer, I might have shortened this discourse as to its present subject; but added much more by the way of improvement of it to other purposes. For tho I shall not rashly anticipate the *Ἐκπύρωσις*, before the triumph be legally decreed by the Philosophical Senate, at whose feet I humbly lay this performance: yet I persuade my self, that if what I have said concerning the Structure and motion of this Automaton, holds true; it may be made (upon the same principles and in a more capacious fabrick,) one of the Noblest Machines of Wheel work, that is yet known; so as to represent the entire Systeme of the Heavens, and that by a more natural imitation, and with fewer uncertainties in the motion, and with much less trouble in the keeping, then any movement that I (in this obscure place) have yet hard of. But it will be time enough to consider that, when I shall find how far the society approves of this: whose bare judgment shall be to me under all my present confidence, of farre greater moment then ten thousand reasons of my own. 'Tis indeed only a domestic Time-keeper (if that be any objection against it) intended for a steady regular motion at home, and not for wandring abroad: accommodated to the ready service of the industrious Student, and a fit companion for Books, among which it may possess a Shelf; and by it's Mystick Frontispiece teach the sober Spectator more true wisdom (namely, that of knowing how to Number and spend his daies;) then great massy volumes that contain nothing but Ink and Paper: I am very sorry, that I am not where I might have provided the Movement my selfe, and without the help of a Carrier, or the trouble of a journey, have presented it to you with my own hands instead of the Scheme and Notion; which would have been a conviction beyond all other demonstrations: But and if in my present circumstances I have attempted my utmost to obey your commands; I hope it will be no less to your acceptance, then it has been to the satisfaction of

Your most affectionate Friend and Servant

Sibbertoft
May. 22. 84.

M. WHEELER.